A REPORT ON

ARMY PARTICIPATION IN PROJECT VANGUARD

MAY 1959

CORPS OF ENGINEERS, U. S. ARMY
ARMY MAP SERVICE
WASHINGTON 25, D. C.

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FOREWORD

The Ionian geographers of the fifth and sixth centuries B.C. believed the earth to be a disk floating in the oceans. In the time of Aristotle the idea of a spherical earth was well established. Eratosthenes of Alexandria, in the third century B.C. measured its size with an error of less than fourteen percent. Geodesists and cartographers of today still strive to perfect the determination of the size and shape of the earth, to locate and delineate its features with the utmost of precision, and to represent its surface accurately on the media most useful to man's many endeavors.

The earth satellite program of the International Geophysical Year (IGY) promised a new tool to geodesy and mapping. The Army Map Service (AMS) is, therefore, proud to have had a part in this program, which has fulfilled its promise. The following report of participation in Project Vanguard, as prepared by Lt Col W. E. Smitherman, Chief of the project for AMS, is presented as a resume of AMS activities in the tracking program for the earth's first artificial satellite.

It is regretted that all individuals who contributed to the success of the program cannot be recognized individually by mention in this report, by name, Inclusion of these names would make this report too voluminous. Accordingly, the report is impersonal. It is hoped that all persons who aided the Army Map Service in this project may know by this foreword that their efforts are duly appreciated.

F. O. DIERCKS
Colonel, Corps of Engineers
Commanding

BACKGROUND

Being endowed with an insatiable curiosity, man's interest in the mysteries of space probably began at the moment the first man first raised his eyes from his immediate earthly surroundings. Ancient civilizations, in both hemispheres, left pictorial indications of the bewilderment they felt at the wonders of the universe. The ancient Egyptians evinced deliberate scientific interest in the regularities of the universe and predicted and used spatial phenomena for mystical as well as practical purposes. Galileo's telescope permitted closer observation of celestial bodies and, to the ordered mind, gave much in terms of visual knowledge as well as impetus to the pursuit of knowledge of the reaches of space. Leonardo da Vinci's dreams, turned into practicality by the Wright Brothers, lifted man from his terrestrial bindings by a means which he could control and allowed him to begin his climb to the stars.

Supplementing the mechanical capabilities of the airplane and circumventing the limitations of both man and machine, the age of electronics enabled man to place his instruments, by balloon and rocket, beyond his flyable ceiling. He could then sample, in limited areas, the ambient conditions which he might expect to encounter should he be able to enter those areas. Such a sampling was a significant portion of the program for the International Geophysical Year established for 1 July 1957 thru 31 December 1958. The scientific program for launching a small, unmanned, earth-circling, instrumented earth satellite was stimulated by a resolution passed by the Special Committee planning the International Geophysical Year at its Rome meeting in October 1954. The project was sponsored by the National Academy of Sciences and the National Science Foundation as part of the U. S. program for participation in the IGY.

On 29 July 1955, Secretary of Defense Wilson announced the participation of the Department of Defense in this program. He stated that technical advice and assistance would be provided to the program by the scientists of the DOD, who had long been engaged in the exploration of the upper atmosphere.

On 9 September 1955, the Secretary of Defense announced DOD responsibility in a tri-service program to launch a scientific satellite during the period of the IGY and assigned management of the technical program to the Navy Department. The Secretary of the Navy directed the Chief of Naval Research, on 27 September 1955, to execute the Navy's portion of the program. On 6 October 1955, the Chief of Naval Research requested the Director of the Naval Research Laboratory (NRL) to proceed with the project, thereafter known as Project VANGUARD.

The purview of this report is limited hereafter to the Army's responsibilities for the installation, operation, and maintenance of

a portion of the "MINITRACK" satellite tracking system.

SITE RECONNAISSANCE

Between 27 March and 11 May 1956, a Site Selection Team composed of representatives of the Chief of Engineers, Chief Signal Officer, and the Director, Naval Research Laboratory, made an extensive reconnaissance to locate suitable tracking station sites. The team was accompanied in South America by a representative of the Inter American Geodetic Survey (IAGS). This team based its site selections upon criteria furnished by NRL which are of interest to note here. In addition to a minimum size of approximately 750 by 750 feet, some of these were:

a. Station locations generally along the 75th meridian of west longitude in northern Florida, Cuba, Panama Canal Zone and at approximately 0°, 12°, 24°, and 34° south latitude.

b. Sites on virgin ground with no fill. Levelling from greater height permissible to attain difference of elevation of plus or minus 5 feet.

c. Adjacent terrain height should be under 10° elevation for at least 1/2 mile, increasing to 20° at five miles.

d. Maximum use of existing roads.

e. At least two miles from high-tension power lines, large power plants, or large power users.

f. At least 5 miles from airways or airports unless tight air-craft control could be effected during tracking events.

g. Sites within one hour's travel of a major population center.

h. Good optical sighting conditions desirable.

i. All stations to be tied into the existing geodetic triangulation net.

Using these criteria, the team selected sites at the following locations:

a. Fort Stewart, Georgia, (selected because of airways congestion in Northern Florida).

b. Batista Field, Havana, Cuba.

c. Rio Hata, Republic of Panama.

d. Paramo de Cotopaxi, Quito, Ecuador.

e. Pampa de Ancon, Lima, Peru.

f. Salar del Carmen, Antofagasta, Chile.

g. Peldehue Military Reservation, Santiago, Chile.

Of these, the Rio Hata station was later deleted since its observations would have been largely redundant to those of Navy stations at San Diego, California and Antigua, British West Indies.

In addition to selection of suitable sites for tracking stations, the Team obtained assurances that the VANGUARD tracking program could be accomplished in Cuba and South America as an extension of the activities of the Inter American Geodetic Survey during the IGY without revision of the basic IAGS mapping agreements.

Descriptions of station sites are part of separate appendices to this report applicable to each station.

STATION CONSTRUCTION

At the request of the NRL, the Chief of Engineers initiated station design and construction in September 1956. District Engineers, Savannah and Jacksonville Engineer Districts were directed to proceed with this work in their respective areas in accordance with specifications established by the NRL. Supervision of construction of stations in Cuba and South America was placed, by the Jacksonville District Engineer, under the Panama Area Engineer, Fort Clayton, Canal Zone. Construction contracts were awarded to the following firms:

a. Fort Stewart Station--
Brittain Construction Co.
Savannah, Georgia

b. Batista Field Station--
Frederick Snare Corp.
Havana, Cuba

c. Cotopaxi Station--
Caribbean Construction Corp.
Coral Gables, Florida

d. Ancon Station--
Mito Fazio & Co.
Lima, Peru

e. Antofagasta Station--
Jorge Razmilic Vlahoric
Antofagasta, Chile

f. Peldehue Station--
Salinas, Fabres & Co, Ltd.
Santiago, Chile

A prerequisite to station construction was the precise location of the station centers in geodetic and astronomic terms. Astronomic and geodetic surveys, locating the station sites with respect to existing first-order triangulation nets, were extended by the following:

a. U. S. Army Map Service

b. Corps of Engineers, Savannah Engineer District

c. U. S. Coast and Geodetic Survey

d. Inter American Geodetic Survey in cooperation with:

(1) Instituto Cubano de Cartografia y Catastro of Cuba

(2) Instituto Geografico Militar of Ecuador

(3) Instituto Geografico Militar of Peru

(4) Instituto Geografico Militar of Chile

Computations to adjust these positions to a common "VANGUARD DATUM" were accomplished by the US Army Map Service.

About these center points, the station antenna system was oriented and constructed. The antenna system is in the form of a 500 foot cross and, since the accuracy of its antenna pattern determines the precision of a station's observations and data, a brief description of some of the location and orientation criteria will be of interest.

a. Position accuracy - plus or minus 0.5 foot per mile with respect to existing first-order triangulation net.

b. Direction accuracy - plus or minus 3 seconds of arc with respect to geodetic north.

c. System level accuracy - plus or minus 1/8 inch in 500 feet.

Government-furnished equipment shipped to the stations included prefabricated buildings, antenna posts and rails, electrical conduit and wire, and, in fact, everything needed for station construction except basic local items such as form lumber and concrete.

A general station description is at Appendix A.

PRELIMINARY OPERATIONAL PLANNING

In discussing preliminary planning, it is appropriate to note some early operational estimates. These were, at the time, considered maximum.

a. The satellite program was to be a United States contribution to the IGY.

b. The VANGUARD program was to be the only U. S. satellite program.

c. One launching attempt would be made each two months during the IGY.

d. Satellite battery life would be two to three weeks, with each station tracking no more than four passes per day.

e. During the five to six week period from battery discharge until the next launch attempt, stations would be on a minimum standby status, meeting one communication schedule per day and keeping critical time-standard equipment in operation.

f. Ample warning of all launchings would be furnished.

Under these criteria, initial personnel planning envisioned requirements for approximately 12 people per station, with everyone "doubling in brass" during the tracking periods and recuperating and resting in the standby periods. How these estimates and plans proved inaccurate will be seen in later discussion of operations.

Original desires for communications would have resulted in a very comprehensive network of radio teletypewriter and voice facilities connecting the VANGUARD Control Center with each station and providing inter-station circuits. The cost estimate for this network was sufficiently high that requirements were reduced to single-channel radio or wire teletypewriter circuits between VANGUARD Control and each station. This system, as initially engineered and installed, proved adequate. In the case of the radio-teletypewriter circuits, experience proved the feasibility of full-duplex, or simultaneous two-way, operation. Engineering had been done on the basis of half-duplex, or one-way, operation and stations were consequently short one receiving antenna. This lack was satisfactorily remedied by local improvisation. Experience also showed the 10 kilowatt radio amplifiers at the three southernmost stations to be needed very rarely.

Radio circuits to South American stations were terminated at Quarry Heights, Canal Zone, and there connected through allocated channels in the Army Washington-Panama 12-channel single-sideband radio system to the Department of the Army Communication Center. Thence, the circuits went by leased land line to the Vanguard Control Center. The overall effectiveness of these circuits has exceeded 98.5 percent.

Leased land-line teletypewriter service between the Control Center and the Fort Stewart station was entirely adequate. To the Cuba station, the original leased circuit consisted of land-line and submarine cable to Havana, and a radio link from Havana to the station. Combinations of troubles in this composite circuit prompted the installation of a direct radio-teletypewriter link between the station and the Department of the Army Communication Center as an alternate route. Improvements in the commercial circuit, however, were of such nature that the alternate link saw very little use except for twice-daily tests.

ARMY MAP SERVICE ENTRY INTO PROJECT VANGUARD

By Department of the Army letter, subject: "Army Participation in Project VANGUARD", 16 October 1956, the Chief of Engineers was assigned responsibility for executing the following specific Army functions under guidance from the Naval Research Laboratory (NRL) and the Chief Signal Officer:

a. Acquisition of real estate and construction of essential facilities for the tracking stations. (This confirmed prior assignment of this function.)

b. Provision of equipment not furnished by the Navy, and the installation, maintenance, and operation of tracking, telemetering, and communications equipment at the tracking stations enumerated under SITE RECONNAISSANCE.

c. Provision of communication facilities (by expansion and utilization of the Army Command and Administrative Network (ACAN) system) to pass the tracking data from the various tracking stations to the data processing center operated by the Navy in the vicinity of Washington, D. C.

d. Provision of trained personnel to operate the tracking stations and communications system.

This same letter assigned responsibilities to:

a. The Chief Signal Officer to support the Chief of Engineers as necessary.

b. The Commanding Generals, Continental Army Command (CONARC) and U. S. Army, Caribbean (USARCARIB) to provide routine administrative and logistic support in their respective areas.

c. The Deputy Chief of Staff for Personnel to provide required personnel spaces.

The Chief of Engineers assigned implementation responsibility for his VANGUARD mission, except land acquisition and construction, to the Commanding Officer, Army Map Service (AMS). CG, CONARC, through Third US Army, designated the CG, Fort Stewart, to support that station. CG, USARCARIB designated the Inter American Geodetic Survey (IAGS) as his operating agency. Direct communications between AMS and Fort Stewart and IAGS were authorized.

The CO, AMS, established a separate operational element within the headquarters which was designated "PROJECT VANGUARD TASK FORCE." In addition to the VANGUARD mission, this element was assigned cognizance of the AMS Project BETTY. This project was initiated and operated to use electronic observations of artificial satellites for geodetic purposes and was, therefore, directly related to and dependent upon the VANGUARD program.

A request was made for the assignment of a Signal Corps officer to AMS as a Staff Advisor. Upon assignment, this officer was designated Chief, Project VANGUARD, AMS, and remained in this position throughout the period of Army participation.

The Chief of Engineers also made an immediate request for 16 additional enlisted power equipment specialists, since by this time it was apparent that stations would have to operate power equipment full-time and perform all echelons of maintenance. This request brought VANGUARD military spaces to 8 officers and 65 enlisted men.

AMS PLANNING AND TRAINING

Project VANGUARD Task Force became operational on 1 February 1957, consisting of:

a. One Colonel, Corps of Engineers, Task Force Chief.

b. One civilian secretary.

c. One Lieutenant Colonel, Signal Corps, Chief Project VANGUARD (actually reported for duty 4 February 1957).

d. The 523d Engineer Detachment (Geodetic Survey) which had been transferred from Fort Bliss, Texas, to operate Project BETTY and

to form the nucleus of the Task Force. The CO of the 523d was designated Chief, Project BETTY. The detachment Operations Officer was made Task Force Operations Officer for both projects and the detachment's one warrant officer functioned as Administrative and Supply officer to the Task Force.

Rather than establish a totally self-sufficient operational element for the VANGUARD function, the Commanding Officer, AMS, directed that the Task Force be supported, as appropriate, by the AMS Staff. The efficacy of this decision is apparent in the success of the mission. Much credit is due the supply, administrative, and fiscal staff elements for accomplishing the added workload. Other staffs have made their contributions also, and all have distinguished themselves by their cheerful and complete cooperation.

By this time, station construction was under way, Signal Corps engineering of the basic communications system was well advanced, and the initial contingent of military personnel were under orders to the AMS. The Task Force settled immediately into the problems of completing plans and arranging for specialized training for the station personnel.

The NRL established a school for MINITRACK and telemetry familiarization. The station chiefs (Army captains), all enlisted electronic technicians of the original contingent, six civilian technicians provided under an Army contract, a number of civilian engineers provided under a Navy contract, and a number of NRL personnel, including the scientists to be assigned to the Army stations, were trained in 4-5 week courses in this school.

Further training in communications was conducted for Army personnel by the US Army Communications Agency (USACA) at the Department of the Army Communication Center, the Transmitting Station at Woodbridge, Virginia, and the Receiving Station at LaPlata, Maryland, for periods of approximately two weeks in each location. Power equipment specialists were trained at the Engineer School, Fort Belvoir, Virginia.

During the period of USACA training, the station chiefs were used by the Task Force to accomplish detailed planning for their respective stations and to assist in overall project planning. Some of the actions accomplished during this period were:

a. Re-evaluation of personnel requirements in the light of more complete estimates of station workload, transportation time, station utilities and housekeeping, and the by-then-apparent lag in the launching vehicle program and consequent compression of the launch schedule. This study resulted in a request for 35 additional enlisted spaces, including clerical and supply specialists. This brought the total enlisted spaces to an even 100. Nine additional spaces, requested for duty assignment

to the USARCARIB Signal Officer, were allocated to USARCARIB instead of AMS.

b. Development of budget requirements for Navy VANGUARD funds to support station installation, operation, and maintenance. It is to be noted that all military personnel costs, with the exception of temporary duty travel, were paid from Army funds.

c. Development of Project Bills of Materials for spare parts, tools, vehicles, administrative equipment, and initial supplies.

During this period, also, the enlisted men were assigned to specific stations. This assignment was accomplished according to individual preference, insofar as possible. An interesting development was that only one man had to be assigned his third choice, all others receiving first or second choice assignments.

As the Minitrack vans were delivered to the NRL, each team participated in the acceptance check of its tracking and telemetry equipment. This included actual operation of the equipment using the antennas at the Navy's Blossom Point, Maryland, prototype station. Signal sources were the sun, radio stars, and airplane-borne simulated satellites.

Approved Bills of Materials for communications equipment were converted, as received, into requisitions. This was accomplished largely by the AMS Supply Division with some help from team personnel.

Amateur radio equipment was provided each team as an alternate communication system. While seldom needed as an alternate means, this equipment proved worth much more than its cost as a means for inter-station discussion of problems as well as for conference-type discussions with NRL and the Task Force. The added morale value of a "phone-patch" to home and other "ham" activities, was tremendous.

The Task Force accepted the job, at the request of NRL, of accomplishing lease of all commercial teletypewriter circuits required for VANGUARD. The total system for which the AMS was ultimately responsible consisted of 16 leased lines and the single-channel radio teletypewriter circuits previously mentioned.

In May 1957, each Team Chief made a trip to his station and to at least one other. All officers were introduced to and oriented by the IAGS in its administrative procedures. During this reconnaissance trip the Team Chiefs made valuable initial contacts and preliminary arrangements for the reception of their teams. The AMS Project Chief accompanied the Team Chiefs on this trip as the first of several periodic visits to the stations. At this time, construction of all stations was well advanced and it was apparent that they would be ready for technical

installation to begin in August. The site contractors were to install all station utilities, the tracking antenna posts and rails, and the towers for communication antennas.

Arrangements were made with the US Army Signal Engineering Agency (USASEA) to provide installation teams for the signal equipment. NRL provided similar teams for the tracking equipment. Arrivals of these teams was planned so that they could be mutually supporting, with both receiving assistance from the station personnel.

STATION INSTALLATION

In July and August 1957, station teams moved to their respective sites. The Fort Stewart team, attached to the garrison there, had fewer problems than those going outside the U. S. They were living and working on familiar ground and had the entire post behind them so that they were able to settle in and go to work without major problems. This should, in no way, belittle their efforts, which were magnificent.

In Cuba and South America, the situation was considerably different. With the exception of the Quito station, discussed in its appendix, contract construction was virtually complete. Team personnel found temporary quarters and installation work began immediately. While installation progress was good on the average, each station had its own peculiar problems. These will be discussed in individual appendices.

Various solutions were found to the problem of permanent personnel housing. These, too will be enumerated in the station appendices but, in general, each Team Chief made his own decision. In every case, the teams lived on the local economy with occasional opportunities to purchase from the Exchange and Commissary in the Canal Zone and obtain shipment of such purchases by military transport.

Many small problems occurred in this period, generally of the "brush-fire" variety. Lost and slow shipments and parts of shipments, transfer of personnel records, and a variety of other activities kept the "wires hot". It was necessary that the station chiefs find their own solutions to many local problems. The experience and familiarity of the IAGS Projects with local conditions and resources was of very valuable aid during this period.

It quickly became apparent that, in initial planning, too much dependence had been placed on local procurement of materiel and services. In the case of support to power units, this was particularly true since it had been expected that practically all parts could be bought locally. It was found that almost none were available. Additionally, it was found that a single 30 kilowatt power unit would not carry the station

load and maintain satisfactory voltage regulation. It was necessary, therefore, to operate two units in parallel at all times. This greatly increased maintenance problems and seriously reduced the standby power capability. AMS initiated two actions to relieve this situation:

a. Secured approval for, procured, and shipped an additional power unit for each station. These units were 45 kilowatt standard military items which were supportable from Army Depot stocks.

b. Prepared a maintenance parts list and provided the stations with an extensive stock of parts for the original 30 kw units as well as the added 45 kw units. While this could be considered a "routine" support function, AMS considered it non-routine in the light of its emergency nature and the requirement for commercial purchase of parts for the 30 kw equipment. After this initial procurement and stocking, the Engineer, USARCARIB, was requested to and did assume support responsibility for power equipment. While the foregoing developed during the station installation period, the actions taken extended well into the period of active station operation which will be discussed later.

Two enlisted clerical specialists were placed on duty with the IAGS in the Canal Zone to augment that headquarters in support of the additional work load. All VANGUARD personnel remained assigned to AMS with duty at their respective sites and were attached to the IAGS for administration and support.

Since operational control remained with AMS, the need for a liaison officer in the Canal Zone prompted the assignment of an additional officer to the VANGUARD Task Force. This officer was furnished by the AMS without additional authorization. He was placed on temporary duty with the IAGS in July of 1957 to represent the Task Force and to assist the Director, IAGS, as necessary in VANGUARD matters. The direct liaison thus effected was instrumental in the rapid solution to many mutual problems.

In early September 1957, the VANGUARD Task Force Chief departed AMS for overseas assignment. Reorganization effected at this time resulted in the Commanding Officer, AMS, assuming the position of Task Force Chief. The BETTY and VANGUARD Projects became independent but coordinate operational elements directly under the Commander and remained so until the termination of VANGUARD responsibilities.

As the system neared operational readiness, material was prepared and sent to the stations for on-the-job training and testing of team abilities. Chart recordings of simulated satellite passes were made at Blossom Point. These were duplicated at AMS and shipped in coded packages to the several stations. It was planned that "dry-runs" would be conducted, under the control of NRL, using these charts for checking the teams' abilities to read-out and transmit the tracking data. It was

expected that these tests would be conducted in the months of October and November 1957, so that the stations would be ready for the first satellite launching event in early December.

OPERATIONS

Tracking practice began with a "bang" on 4 October 1957, when the world learned that Sputnik I had that day become the first artificial satellite of the earth. It will be remembered that this feat was a surprise to the world and it was no less so to VANGUARD. Direct communications had been established to Fort Stewart and Antofagasta. Other stations were nearly ready, but had to be reached by various slower means. Commercial cable, the IAGS radio net, amateur radio, and long distance telephone were all used to pass to the stations the scant technical information available about the Soviet satellite. No preparation had been made for either detection or tracking at the frequencies used. Emergency equipment alterations and antennas were designed. Station teams and the installation crews worked around the clock for several days to make the necessary modifications. A special shipment of radio receivers was sent by air to all stations. Eventually all stations were capable of some tracking at the Sputnik frequencies but the data obtained were approximate, at best. On 26 October, the Sputnik radio faded and all hands breathed a sigh of relief. It was immediately realized that this "wettest dry-run in history" had been a blessing in disguise. The shake-down under pressure, and the realization that they could do the job, did wonders for team and individual morale. It was also now apparent that tracking missions could come without the expected warning and that the Project would have to be prepared for anything. This realization was extremely fortunate since, on 3 November 1957, the Russians launched the second Sputnik. During the six days of its radio life, tracking operations, while still crude, began to approach the routine.

The NRL, meanwhile, made the decision that two of the Army stations, Lima and Santiago, would be given a quick-change capability for the Sputnik frequencies. Other stations concentrated on preparation for tracking US satellites but retained a detection and monitor capability in the 20-40 megacycle range.

December 1958 and January 1959 gave opportunity to apply the training program planned for the previous two months. After the one ill-fated launch attempt in early December, the teams settled down to improvement of their techniques and the physical appearance of the stations. The IAGS obtained necessary personnel authorization and established the VANGUARD Liaison Officer as a member of its Canal Zone Staff. The AMS officer returned to Washington and became Assistant Chief, Project VANGUARD, AMS.

31 January 1958 saw the successful launch of the first US Satellite-Explorer I. There is no doubt that this was a great day for the Army. It was also a great day for the VANGUARD Task Force. At long last, there was a tracking job to be done which was at least approximately that for which preparations had been made. By now, the teams were so completely US and IGY that, except for the inevitable friendly jibes, hardly a thought was given to the fact that an Army cylinder instead of a Navy ball was carrying the signal which made the marks on our charts. Outside the US the tracking stations were considered a part of the IGY contribution of the country in which they were located. The fact that this was an Army satellite made even less difference to the Latin Americans. In Cuba, Ecuador, Peru, and Chile it was "el Explorador" or "el Sputnik Americano" which was circling the earth and it was "Minitrack del Peru", or Ecuador, or Chile, or Cuba, which was tracking the signal and enriching the world's knowledge. The writer was in Latin America during the month of February 1957 and noted that, of the hundreds of questions asked by the press and by private citizens, barely a dozen referred to Explorer as other than the US, or the American, satellite.

For the first time, the stations were receiving the data for which the VANGUARD tracking and computing systems had been designed. Upon attempting to pass this data over the teletypewriter system into the computer, a problem arose which had been entirely omitted from original planning. It had been expected that, if the data were transmitted accurately as to numerical content and group spacing, the computer would do the rest. It developed, however, that a great deal more precision in message preparation was required. The computer could not tolerate the teletypewriter operators' means of message correction, the "letters" machine function as a tape "rub-out". Additionally, other machine functions used in the data messages had to be exactly placed in the tape. In the interest of speed as well as accuracy, it was found necessary to abandon the idea of teletypewriter operation as an additional duty for other specialists and to provide the stations with qualified operators. It was also determined that those stations having radio teletypewriter equipment needed Radio Supervisors. Accordingly, request was made for 34 additional enlisted spaces in these specialties. This was approved and brought the Task Force authorized strength to eight officers, 134 enlisted men, six contract civilians, and one civilian secretary.

On Saint Patrick's day in 1958, the long-awaited VANGUARD I satellite was orbitted. Although much derided as the "grapefruit," the orbit of this 4-pound sphere was superior to previous ones and we of the Task Force rejoiced with the NRL at the vindication of its planning. Thanks to the experience gained on Explorer, station teams were able to track VANGUARD I so successfully that, after a few days, the computer was able to determine the orbit with a high degree of

accuracy and the requirement for rapid data was relaxed.

The launching of Explorer III on 26 March 1958 proved the validity of planning for full-time tracking. There were three US satellites in orbit and all were emitting a trackable signal. Instead of the three or four passes per day, each station was now recording 10 to 15. This busiest period lasted for almost two months. By the end of that time, satellite tracking was a routine business for which each station team felt well-qualified.

Of the other satellites orbitted during the period of Army participation, only 1958 Zeta caused any excitement. This one, Project SCORE, was launched in almost complete secrecy. It was only after completion of its first orbit, and the subsequent public announcement, that VANGUARD was given its frequencies. These were such as to require complete retuning of the MINITRACK system. Never-the-less, VANGUARD stations recorded the third, and tracked the fourth and subsequent orbits. This was a considerable tribute to the capabilities of the station teams to meet and deal quickly with the unexpected.

A significant test of initial station location criteria occurred at the Lima station. It will be remembered that one specification had been isolation from high-tension power lines. Early in 1958 construction was started on a 15 kilovolt line along the Pan American Highway some 700 meters from the Lima station. Progress of this line was watched with considerable interest and some trepidation. When it was energized, however, no interference to station equipment was noted. It was decided, then, to install commercial power to the Lima station. Although this project was initiated, it was not yet completed at the end of the Army's period of participation.

Extensive modifications to the Fort Stewart station began in mid-1958. These changes made that station part of a special-purpose east-west fence and effectively removed it from the IGY MINITRACK system.

The Cuba station team experienced some anxious times during the early days of 1959 when the government of Cuba was overthrown by the "26th of July" revolutionary movement. The station was closed on New Years' Day, as a precautionary measure, and reopened on 6 January. No damage occurred to the station, nor was it molested in any way. One vehicle was lost but personnel were not harmed. The remaining vehicles and a number of the station personnel were placed at the disposal of the American Embassy and assisted in the evacuation of tourists from Havana.

This report would be incomplete if it did not pay tribute to the invaluable assistance received from others. On the stations, the services of the Navy scientists and contract personnel were indispensable.

Had these personnel not been provided by the NRL, it would have been necessary that their equals be furnished by the Army. In retrospect, it can be said that the AMS Task Force would have wanted the same individuals.

The Inter American Geodetic Survey, for its own direct support and for its coordination of the support of other USARCARIB elements, deserves a sizeable amount of credit for the success of the tracking mission. Its Liaison Officer to AMS has been one of the most valuable unofficial members of the Task Force.

Without the constant attention of the personnel at the D. A. and USARCARIB Communication Centers, the quality, dependability and speed of communications would have been much degraded. This would have seriously reduced the value of tracking data.

To the staffs of the Army Map Service, the Chief of Engineers, the Chief Signal Officer, and others of the Department of the Army goes credit for the many supporting actions taken as well as the freedom of operation and direct liaison granted the Task Force.

Last, but by no means least, the VANGUARD Group of the Naval Research Laboratory must be thanked for their guidance, understanding, and ready assistance.

TERMINATION OF ARMY RESPONSIBILITY

The 85th Congress, by the National Aeronautics and Space Act of 1958 (Public Law 85-568), established the National Aeronautics and Space Administration (NASA). Executive Order of the President Number 10783, 1 October 1958, transferred to the NASA all functions of the Department of Defense with respect to Project VANGUARD.

Plans were placed in effect to support the NASA until it could prepare for operation of the tracking stations and to effect the transfer without loss of operational effectiveness. The NASA agreed to provide not less than 60 days notice of its readiness to accept responsibility for the tracking stations and to continue the Army's responsibilities therefor until the date of transfer. On 30 December 1958, this notice was received and the time of transfer set as midnight 28 February 1959. By subsequent arrangements, time was reduced for the Fort Stewart station to 31 January 1959. NASA contract technical personnel were phased into the stations by early January and an intensive training program pursued during the intervening two months. Contract administrative personnel were procured locally and integrated into the teams. Army personnel, withdrawn by normal attrition, were replaced in operational positions by civilians so that by 28 February only a handful of enlisted men remained.

All station property had been accepted by the designated NASA representatives by 28 February. Therefore, on 1 March 1959, the transfer had been completed and the stations were in NASA hands.

Department of the Army letter AGAM-P(M) 676.3 (26 Feb 59) DCSLOG, 27 February 1959, subject: "Army Participation in Project VANGUARD," rescinded the 16 October 1956 letter, same file and subject, and thereby officially terminated Army responsibilities. Of course no change is completed so abruptly. There were actions in progress, such as supplies already in the pipeline, which must be pursued to conclusion. Fiscal accounting remained to be completed. Operationally, however, the Army had accomplished its mission of helping to track the earth's first nine artificial satellites and thereby had contributed toward the satisfaction of man's curiosity concerning his environment.

CONCLUSIONS

Two years of experience in the VANGUARD Program leads to a number of conclusions. Most of these are believed valid for application to any military activity supporting essentially scientific projects of world-wide interest. They are presented here for consideration in future similar missions.

a. The earliest possible assignment of responsibility to an operating and supporting element is, at best, not too soon. Many "crash" actions in this program could have been avoided if the Project VANGUARD Task Force had been able to grow and plan with the Project.

b. All responsibilities should be placed in one operating and supporting element. That element should be as close as possible to the managing scientific agency. The ideal proximity is the one which allows the operating element to feel it has a part in the program rather than simply a task assigned by higher authority. This engenders pride in the program and eliminates much inter-agency rivalry and jealousy. From the point of view of the supported agency, proximate location also tends to inspire confidence in the capabilities of the operating element.

c. Maximum freedom of action is imperative. It was enjoyed in this mission and is considered one of the major reasons for successful execution. Being essentially a laboratory operation, the program was subject to many sudden changes in procedures and requirements. Response to these changes was necessary, often, in a matter of a few hours.

d. Appropriate priority must be given to guarantee adequate response of fiscal, personnel, and supply activities. Coupled with direct communication authority, this assures support when and as needed.

e. Isolated sites, such as the VANGUARD stations in Latin America, should include living facilities for unmarried men. One of the major problems of this mission was that of personnel transportation between working and living locations.

f. Regardless of the fact of attachment to a headquarters, it will be found that a Team Chief will have to accomplish many administrative and command functions. These should be planned for and adequate types and numbers of personnel provided, to include an assistant Team Chief. Since control of an isolated team amounts to command, the Team Chief should also be vested with the authority of a commander.

g. Most instructions and orders will be passed orally or by message. Formal letters were found too time-consuming even for the purpose of confirming messages. A rapid, direct communication system is a must, as is the willingness to accept orders without a signed signature. Two additional factors relating to communications are noted:

(1) Most circuit outages were caused by equipment failure.

(2) Extensive informal discussions of technical matters were necessary. These did not need to be recorded and were very slow and laborious when conducted by teletypewriter.

Duplicate radio equipment with a voice channel in addition to the teletypewriter channel would have been much more useful. In lieu of the seldon-used high-power amplifiers, such a system probably could be provided at little added cost.

h. Outside the U. S., it is important that host countries feel themselves a part of the activities. For this reason, much emphasis was placed on the tracking activities of Project VANGUARD as a contribution of the host countries to the IGY. Consequently, no classified activities were permitted and regular visiting hours were maintained. When it was necessary to exclude visitors from station technical areas during tracking operations, the exclusion period was kept as short as possible and frank explanation was made. These practices are highly recommended for good public relations.

i. Station power supplies require a better ratio of single-unit capacity to connected load in order that parallel generator operation may be reduced to a minimum. This shortcoming in the VANGUARD Project was due to demand load increase after power equipment was ordered. Allowances for such growth should be applied in engineering future similar installations.

Distribution systems should be based upon electronic, rather than electrical, engineering principles to eliminate, as much as possible, voltage variations intolerable to sensitive equipment.

SUBMITTED BY:

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APPENDIX A

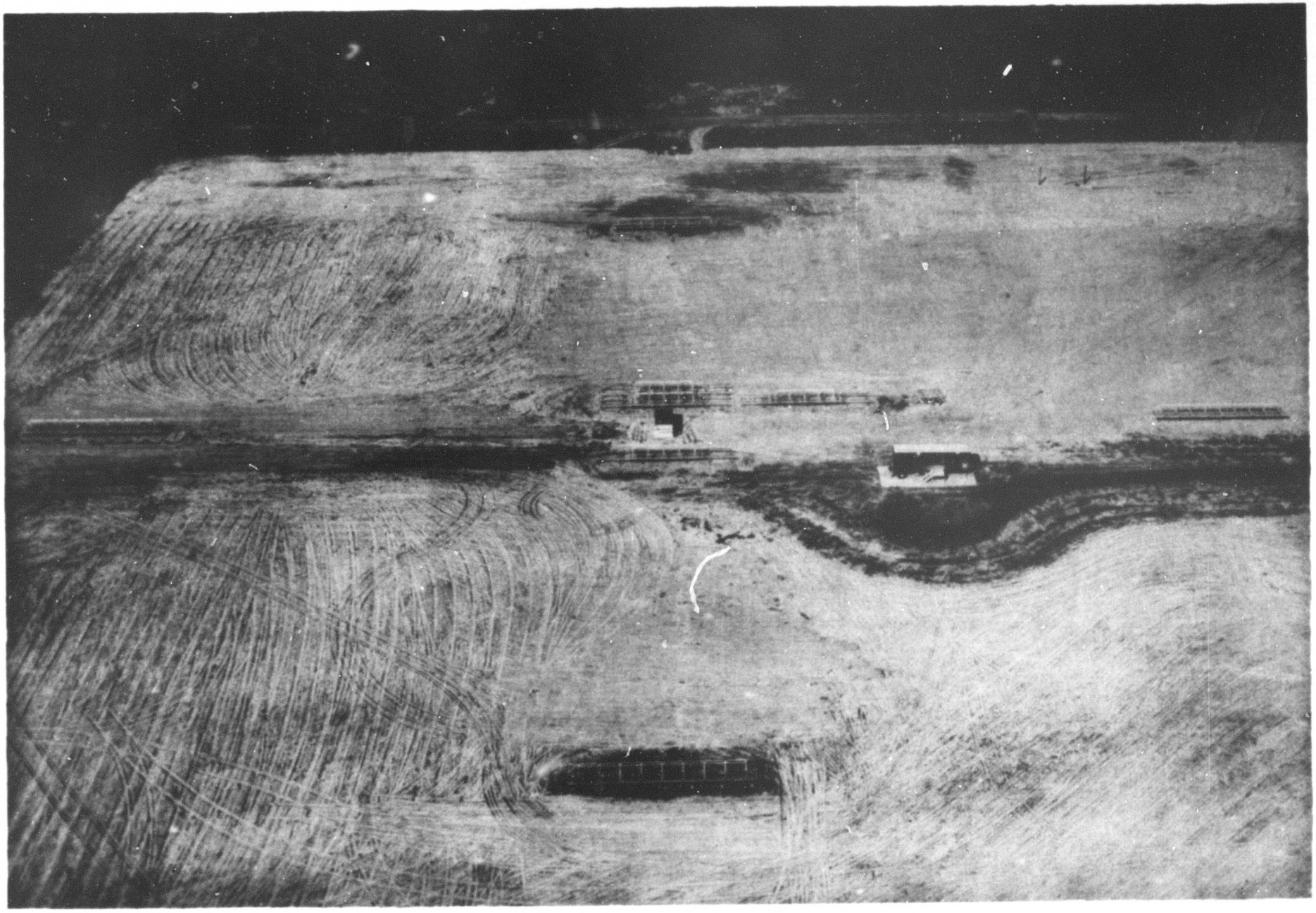
GENERAL DESCRIPTION OF A MINITRACK STATION

MINITRACK is a system for angle tracking of a radio source by the phase comparison method. Tracking stations measure north-south and east-west angles to and the time of transit of the radio source - in this case, the satellites. The system has been technically described in many publications so this appendix will be limited to a general physical site description.

The accompanying photograph of the Fort Stewart station shows the layout of the tracking components. The top of the photo (woods and road) is north. A line drawn through the centers of the upper and lower antennas would pass through the center of the system (in the small white building) in a precise geodetic north-south direction. The other antenna axis is precisely 90 degrees from this. Each leg of the cross, to the antenna centers, is 250 feet in length. Specifications for grade, orientation, and level have been given in the main portion of this report.

The small building in the center of the antenna field houses an astronomical camera used in station calibration. The trailer at the right center of the photo houses receiving, amplifying, time standard, and recording equipment of the MINITRACK system. Connections to the antennas are by buried pressurized coaxial cables.

The portion of the station shown in the photo is typical of all stations. Not shown, but also a part of each station, are a headquarters building, a power unit shelter, a telemetry receiving antenna trainable within limits in an east-west direction, and a telemetry turn-on antenna. Telemetering command turn-on and receiving and recording equipment are in the headquarters building. Antennas for radio communications, where used, are outside the station compound. All station areas are fenced for traffic exclusion but not for security.



Photograph to Accompany Appendix A—Minitrack Station, Fort Stewart, Georgia

APPENDIX B

VANGUARD STATION #2
Fort Stewart, Georgia

LOCATION

On the Fort Stewart Military Reservation approximately 16 miles northeast of Post Headquarters.

Geographic coordinates station center:

Latitude	31°	59'	07.805" N
Longitude	81°	29'	41.960" W

Center elevation: 10.21 meters

AREA DESCRIPTION

A very flat section of Georgia having clayish sand soil. Water table is very close to the surface resulting in many swampy areas. Some clearing and topping of surrounding timber required for antenna pattern clearance.

COMMUNICATIONS

Leased land-line teletypewriter.

TEAM

Arrived July 1957

Composed of: 1 Officer
20 Enlisted Men
1 Civilian (Army Contract)
3 Civilians (Navy Contract)

Housing: Post quarters

PECULIAR PROBLEMS

None

APPENDIX B (Continued)

RESUME OF OPERATIONS

Station operated normally until July 1958 when it was modified as a part of a special-purpose east-west fence. This change involved complete replacement of the antenna system and some modification to equipment. The new mission required constant visual watch on recording equipment. Except for the fact that new contract personnel were placed at the station for training, addition of approximately ten men to the team would have been necessary.

Station was transferred to the NASA on 31 January 1959.

APPENDIX C

VANGUARD STATION #3
Havana, Cuba

LOCATION

On a Cuban Army Air Force Base near San Antonio de los Banos, Cuba, approximately 37 kilometers south and slightly west of Havana.

Geographic coordinates--station center:

Latitude 22° 52' 18.132" N

Longitude 82° 31' 26.120" W

Center elevation: 43 meters

AREA DESCRIPTION

A relatively flat area having a reddish-black sandy-clay soil. Scattered palm trees constitutes the only tall vegetation and are clear of the runway and approach areas. Low vegetation and grass is lush. Semi-tropical rainfall keeps soil wet and mud is a problem.

COMMUNICATIONS

Leased teletypewriter circuit composed of land line, submarine cable, and VHF radio teletypewriter.

Amateur radio - voice and radiotelegraph--500 watts.

Radio teletypewriter installed in early 1958 as back-up to leased line. Power--1 kilowatt.

TEAM

Arrived July 1957

Composed of: 1 Officer
19 Enlisted Men
1 Navy Scientist
1 Civilian (Army Contract)
3 Civilians (Navy Contract)
4 Native Labor

Housing: Local economy for all.

APPENDIX C (Continued)

PECULIAR PROBLEMS

The tense political situation plus location on an Army Base caused some uncomfortable situations. It was necessary at times to schedule personnel so that all movement was accomplished in daylight.

RESUME OF OPERATIONS

Station operated normally until 1 January 1959. Due to revolutionary activities, station was closed on that date and reopened on 6 January. One vehicle was lost but neither station nor personnel were harmed.

Public relations support was handled by the U. S. Information Service attached to the Embassy. This agency was highly interested in the station and the IGY. Publicity was frequent and excellent.

Station was transferred to the NASA on 28 Feburary 1959.

APPENDIX D

VANGUARD STATION #5
Quito, Ecuador

LOCATION

On a windy plain on the northern slopes of Mt. Cotopaxi about 55 kilometers south of Quito.

Geographic coordinates--station center:

Latitude	0°	37'	21.751" S
Longitude	78°	34'	45.230" W

Center elevation: 3,567 meters

AREA DESCRIPTION

A high, grass-covered plateau with a soil composed of volcanic silt, sand, and clay. Local name--PARAMO DE COTOPAXI. Soil is visibly stratified in road and similar cuts, showing the deposits of volcanic material. Mt. Cotopaxi is considered a dormant volcano and the area is subject to frequent seismic tremors typical of the Andean Range. The land is part of a privately owned grazing tract and was leased from the owner.

COMMUNICATIONS

Radio teletypewriter to the Canal Zone. Power--1 kilowatt.

Amateur radio - voice and radio telegraph--500 watts.

TEAM

Arrived August 1957.

Composed of: 1 Officer
23 Enlisted Men
1 Navy Scientist
1 Civilian (Army Contract)
3 Civilians (Navy Contract)
6 Native Labor

Housing: U. S. Government leased quarters for unmarried personnel. Local economy for families.

PECULIAR PROBLEMS

Communication antenna towers were not erected by the site contractor as at the other South American sites. This installation had to be made by the Signal installation team and was a major factor in the time required to complete the station.

Altitude of the station site and almost continuous cloud cover precluded calibration of the station by aircraft. Station personnel experienced some altitude acclimation difficulties.

The road between Quito and the station site was very rough and the trip required 1½ to 2 hours. This caused excessive fatigue to personnel and a serious maintenance problem for vehicles. This section of the Pan American Highway is part of the ancient Inca Highway and is still paved and repaired in the Indian way. There is no roadbed stabilization and paving material is river rock. All maintenance is by hand.

Station water supply is a spring which was periodically contaminated and could never be considered safe.

RESUME OF OPERATIONS

Station operated normally throughout the period.

Due to excellent publicity by the U. S. Information Service and active effort on the part of individual Ecuadorians, local interest was very high. In spite of the remote location, there were more than 5,000 visitors during the period. Official visitors included the Vice-President of Ecuador and most of the Government Ministers.

Station personnel took an active part in community life and especially in sports.

After the initial equipment, most shipments were made by military aircraft from the Canal Zone.

Station was transferred to the NASA on 28 February 1959.

APPENDIX E

VANGUARD STATION #6
Lima, Peru

LOCATION

On Peruvian Government land, approximately 36.5 kilometers northwest of Lima and about 700 meters to the right of the Pan American Highway near an emergency landing strip. The resort town of Ancon is approximately 5 kilometers distant to the west.

Geographic coordinates--station center:

Latitude	11°	46'	36.492" S
Longitude	77°	09'	01.816" W

Center elevation: 49 meters

AREA DESCRIPTION

A hard-packed sand desert with occasional volcanic rocks. Local name--PAMPA DE ANCON. The station area is protected from drifting sand by a low range of seaward hills. Soil movement due to winds is limited to a few inches above the surface and locally called "dancing sand". The desert supports no natural growth although, with adequate water, grass and other vegetation can be maintained. The Pan American Highway provides excellent access to the city of Lima. Area is subject to some earthquakes.

COMMUNICATIONS

Radio teletypewriter to the Canal Zone. Normal power--1 kilowatt. 10 kilowatt amplifier provided but seldom used.

Amateur radio - voice and radiotelegraph--500 watts.

Commercial telephone to Lima.

TEAM

Arrived August 1957.

Composed of: 1 Officer
23 Enlisted Men
1 Navy Scientist
1 Civilian (Army Contract)
3 Civilians (Navy Contract)
6 Native Labor

Housing: Local economy for all. Unmarried men in pension (boarding house).

PECULIAR PROBLEMS

None

RESUME OF OPERATIONS

Station was provided a quick-change dual-frequency capability after the launch of the first Soviet satellite.

Operation was normal throughout the period.

Installation of a 15-kilovolt power line along the Pan American Highway proved no detriment to station operation and led to installation of commercial power to the station.

Local interest was quite high due to USIS-managed publicity and the efforts of the Peruvian IGY Committee. Proximity to the town of Ancon and the Pan American Highway also contributed to the numbers of visitors.

Recreation facilities were plentiful and morale was continuously high.

Station was transferred to the NASA on 28 February 1959, with a formal ceremony on the following day.

APPENDIX F

VANGUARD STATION #7
Antofagasta, Chile

LOCATION

On Chilean Government land approximately 15 kilometers northeast of Antofagasta along the Calama-Chuquicamata road. Station site lies about 700 meters to the right of this road, which is a section of the Pan American Highway.

Geographic coordinates--station center:

Latitude	23°	37'	15.993" S
Longitude	70°	16'	23.162" W

Center elevation: 519 meters.

AREA DESCRIPTION

The station site is on a bare desert plain lying between the coastal hill range and the first inland mountain range. Local name for the general area--SALAR DEL CARMEN. Soil is composed of alternate layers of sand, with some small fragments of shale and volcanic stone, and a hard sedimentary material with considerable nitrate content. Sand storms, almost a daily occurrence, are caused by winds from the west reaching 30-40 knots. This led to the station being dubbed "Tunnel of Winds." In spite of the nitrate content of the soil, natural vegetation is absent and growth can be maintained only by deep cultivation and irrigation. Rainfall is negligible.

The city of Antofagasta is the second port of Chile, being the ocean shipping point for the nitrate and copper mining industries inland as well as the port serving the country of Bolivia via railroad. The name, from the Quechua language, means "great salt flat" and is descriptive of South America's Pacific coast desert which extends from Ecuador's southern border to Valparaiso, Chile.

COMMUNICATIONS

Radio teletypewriter to the Canal Zone. Normal power--1 kilowatt. 10 kilowatt amplifier provided but seldom used.

Amateur radio--voice and radiotelegraph--500 watts.

TEAM

Arrived August 1957.

Composed of: 1 Officer
24 Enlisted Men
1 Civilian (Army Contract)
4 Civilians (Navy Contract)
6 Native Labor

Housing: Local economy for all. (Enlisted men rented house on a cooperative basis).

PECULIAR PROBLEMS

The isolation and uninviting physical appearance of Antofagasta and its surrounding area present serious personal adjustment problems. If the first impression can be endured, these detriments are quickly cancelled by the sincere friendliness of the population. It is significant and a tribute to the personnel assigned to this station that it was necessary to remove only four persons because of inability to accomplish personal adjustment. One of these was military.

Almost no materiel support was available. Some vehicle maintenance and local fabrication services were used but, in the main, the station had to be self-sufficient.

The nearest military supporting agency was in Santiago--some 700 miles. This contributed to the feeling of isolation.

Recreation facilities of the type to satisfy the needs of the young soldier are almost non-existent. VANGUARD personnel, in the face of this situation, provided their own recreation. A baseball team composed of station personnel, and another of local grade school boys sponsored and equipped by the VANGUARD crew, captured high honors in local competition. These and other self-developed activities contributed to the outstanding morale at this station. Of no less importance was the acceptance of and friendly attitude toward the station on the part of the local populace.

Only by constant attention and work were the maintenance problems created by blowing sand kept from degrading station operation.

RESUME OF OPERATIONS

Station operated normally throughout the period. Although its

product was no better than that of others, in the light of overall conditions it must be considered the model station of the Army-operated fence.

Local interest was extremely keen. Publicity by the local newspaper was frequent and always excellent. Chilean military elements in the area gave unstinting support. Liaison officers from the Chilean Air Force Base were especially outstanding in their concern with and assistance to the station, reflecting the interest of the Base Commander and the Air Force. Local customs officials and transportation agencies gave such attention to materiel shipments as to practically eliminate difficulties experienced elsewhere. The US Consul gave much of his official and personal time in support of the station activities and personnel. The above should indicate that a great deal of credit for the success of Station #7 belongs to the people of Antofagasta.

Initially attached to Chile Project, IAGS, the station was later made administratively and logistically independent of that Project. The station chief then dealt directly with Headquarters, IAGS, for all such support, including Class B funds.

The station was transferred to the NASA on 28 February 1959.

APPENDIX G

VANGUARD STATION #8
Santiago, Chile

LOCATION

On a Chilean Army Reservation approximately 36 kilometers by road north of Santiago (measured from the Presidential Palace). Station site about 700 meters west of the road from Santiago through Colina to Los Andes.

Geographic coordinates--station center:

Latitude	33°	08'	58.106" S
Longitude	70°	40'	08.717" W

Center elevation: 695 meters

AREA DESCRIPTION

The station site is a part of a natural bowl in the Andean foothills. Local area name--FUNDO PELDEHUE. Characteristic soil is an almost black silty clay over gravel mixed with conglomerate material. Although a part of a military reservation, the area is under irrigated grain cultivation. In dry seasons, unirrigated ground developes cracks up to two inches in width. Surrounding hills and mountains lie at such distance that antenna pattern clearance criteria were barely met.

COMMUNICATIONS

Radio teletypewriter to the Canal Zone. Normal power--1 kilowatt. 10 kilowatt amplifier provided but seldom used.

Amateur radio--voice and radiotelegraph--500 watts.

Commercial telephone to Santiago.

TEAM

Arrived August 1957

Composed of: 1 Officer
22 Enlisted Men
1 Navy Scientist
1 Civilian (Army Contract)
3 Civilians (Navy Contract)
6 Local Labor

Housing: Unmarried enlisted men initially in Government leased quarters, later on local economy in 3-4 man apartments. Families on local economy.

PECULIAR PROBLEMS

None

RESUME OF OPERATIONS

Station was provided a quick-change dual-frequency capability after the launch of the first Soviet satellite.

Operation was normal throughout the period.

Due to the distance to the port of Valparaiso, the station experienced considerable difficulty with ocean shipping and customs clearance.

Station was transferred to the NASA on 28 February 1959.